IN THE CLAIMS

Please amend the claims as follows:

1. (currently amended) A method of forming a layer of metal on a substrate, comprising:

i) depositing a seed layer of the metal on a first substrate surface which is Ti, said seed layer being sufficient to cover said first substrate surface which is Ti at a substrate temperature of from ~~220~~ 250 to 300°C;

ii) depositing a second amount of metal on said seed layer at a substrate temperature and power that are sufficient to (i) inhibit formation of filamentous metal phases having a resistivity greater than that of said metal, and (ii) provide a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0; and

iii) depositing a third amount of metal on said second amount of metal.

2. (original) The method of Claim 1, wherein said substrate further comprises an opening.

3. (original) The method of Claim 2, further comprising, before step i) forming a barrier/liner layer in said via channel.

4. (original) The method of Claim 3, wherein step ii) is conducted at a substrate temperature and power sufficient to inhibit formation of filamentous metal phases with said barrier/liner layer, having a resistivity greater than that of said metal.

5. (original) The method of Claim 1, wherein said second amount of metal is deposited at a rate of about 5 to 30 Å/sec.

6. (original) The method of Claim 1, wherein said second amount of metal is deposited at a pressure of 4 to 6 mtor.

7. (original) The method of Claim 1, wherein said second amount of metal is deposited at a substrate temperature of 300 to 420°C.

8. (original) The method as in Claim 1, wherein said second amount of metal is deposited to form a layer of 400 to 3,000 Å thick.

9. (original) The method as in Claim 1, wherein said metal is aluminum.

10. (original) The method as in Claim 1, said seed layer is deposited at a power of 9,000 W.

11. (original) The method of Claim 1, wherein said seed layer is deposited at a pressure of 1 to 3 mtorr.

12. (original) The method of Claim 1, wherein said seed layer is deposited at a rate of 100 to 300 Å/sec.

13. (original) The method of Claim 1, wherein said seed layer is deposited to form a layer of 500 to 4,000 Å.

14. (original) The method of Claim 1, wherein heating of said substrate in said second step is by backside gas flow.

15. (original) The method of Claim 14, wherein said gas is Ar.

16. (original) The method of Claim 2, wherein said opening has an aspect ratio of at least. 3:1 (W/H).

17. (original) The method of Claim 2, wherein said second amount of metal deposited is sufficient to fill said opening.

18. (original) The method of Claim 2, further comprising forming a liner/wetting layer is deposited in said opening before step i).

19. (original) The method of Claim 1, wherein said second amount of metal is deposited at a power of 100 to 800 W.

20. (original) The method of Claim 2, wherein said opening has an aspect ratio of at least 2.5 (W/H).

21. (canceled)

22. (currently amended) A method of forming a layer of aluminum-containing metal on a substrate, comprising:

i) depositing a first amount of a metal comprising aluminum on a seed layer of the metal, said seed layer being sufficient to cover a substrate surface comprising titanium, at a substrate power sufficient to inhibit formation of a phase of $TiAl_3$ having a resistivity greater than that of said metal said seed layer of metal being deposited at a substrate temperature of from ~~220~~ <u>250</u> to 300°C; and

ii) depositing a second amount of metal on said first amount of metal.

23. (previously presented) The method of claim 22, wherein said first amount of said metal is deposited at a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0.

24. (currently amended) A method of forming a layer of aluminum-containing metal on a substrate, comprising:

i) depositing a first amount of a metal comprising aluminum on a seed layer of the metal, said seed layer being sufficient to cover a substrate surface, at a substrate power

sufficient to inhibit formation of a phase containing said metal having a resistivity greater than that of said metal and at a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0 said seed layer of metal being deposited at a substrate temperature of from ~~220~~ 250 to 300°C; and

ii) depositing a second amount of said metal on said first amount of metal.

SUPPORT FOR THE AMENDMENT

Support for the amendment to claim 1 is found in example 1 on page 19 of the specification. No new matter would be entered into this application by entry of this amendment.

Upon entry of this amendment claims 1-20 and 22-24 will remain active in this application.

REQUEST FOR RECONSIDERATION

The present invention is directed to a method of forming a layer of metal on a substrate.

Applicants wish to thank examiner Toledo for the helpful and courteous discussions held with their U.S. representative on July 9, 11 and 14, 2003. At that time, the examiner indicated that claims amended to clarify the conditions for depositing the seed layer would be allowable. More specifically, claims amended to recite a substrate temperature of 250 to 300°C, would be allowable. The following is indented to expand upon the discussion with the examiner.

During the formation of semiconductor devices, metallization layers are generally formed in trenches and openings to form interconnects and vias. Formation of such metal layers can sometimes be complicated by difficulties with the conductivity of the metallization layers as a result of too rapid of a processing speed and accordingly rapid yet efficient methods for forming such metallization layers of good conductivity are sought.

The present invention addresses the problem by providing a method of forming a layer of metal on the substrate which comprises depositing onto a seed layer of metal which is formed on a surface, at a substrate temperature of from 250 to 300°C, depositing an amount of metal under conditions sufficient to inhibit the formation of resistive metal phases having a resistivity greater than that of said metal, followed by depositing a further amount of metal. Applicants discovered that a process in which metal which is deposited onto a seed layer of metal is formed at a substrate temperature of from 250-300°C is effective in a method of forming a layer of metal on a substrate. More specifically, Applicants have discovered that such a seed layer allows for the deposition of metal on said seed layer under conditions that are sufficient to inhibit formation of resistive metal phases having a resistivity greater than that of said metal. Thereafter, additional metal may be deposited rapidly, without impairing the conductivity of the final metallization structure. The result is a metal structure having good conductivity properties which is formed in an efficient manner. Such a method is nowhere disclosed or suggested in the prior art of record.

The rejections of claims 1-13, 16-20 and 22-24 under 35 U.S.C. § 103(a) over Xu U.S. 6,217,721 and of claims 14-15 under 35 U.S.C. § 103(a) over Xu in view of Moon, Jong U.S. 5,660,696 are respectfully traversed.

Xu fails to disclose or suggest a method in which a metal layer is deposited on a seed layer covering a substrate surface which is Ti, in which 1) the seed layer is deposited at a substrate temperature of **250 to 300°C**; 2) the first amount of metal is deposited at a substrate temperature and power sufficient to inhibit formation of a filamentous metal phases and

inhibit void formation in an opening having an aspect ratio of at least 2.0; and 3) a further amount of metal is deposited on the surface of the metal deposited on the seed layer.

Xu Fails to Suggest Depositing a Seed Layer on a Substrate Surface of Ti at a Temperature of 250 to 300℃

Xu describes a method, in which a via hole is filled, by cold deposition of a seed layer of Al onto a Ti substrate by sputtering, at a substrate temperature of **only 130°C** or lower, illustrated at column 20, line 11. The reference teaches the preferred cold deposition temperature of a seed layer of Al onto Ti to be **200°C or below** as the dewetting temperature is 250°C (column 24, lines 58-60). Accordingly, the reference expresses a preference for a temperature which is below **250°C** and explains the reasons as at higher temperatures undesired dewetting of the metal occurs.

In contrast, the present invention is directed to a process in which the seed layer is deposited at a temperature of 250 to 300°C. Applicants note that the claims have been amended to recite a deposition temperature of 250 to 300°C.

The examiner agrees that Xu teaches a temperature of **only 200°C** (page 6 of office action November 1, 2002). As the reference clearly teaches away from a temperature of 250°C and above, identifying a temperature of 250° at which the undesired phenomenon of dewetting is observed, the claimed invention is clearly no obvious from this reference.

Moreover, it would not have been obvious to have selected a temperature of 250 to 300°C, as the result of optimization, as 1) the reference teaches that the temperature should **not** exceed 200°C as dewetting occurs at higher temperature; and 2) temperature is not identified as a result effective variable capable of being optimized for a particular result.

As to the first point, the reference identifies a preferred temperature of **200°C or below** as, at a temperature of 250°C, dewetting occurs. The teaching of a preferred temperature range of 200°C or below, with an express teaching of undesired consequences from exceeding the preferred temperature range does not provide any motivation to exceed the temperature range of below 200°C.

> However, while it may ordinarily be the case that the determination of optimum values for the parameters of a prior art process would be at least *prima facie* obvious, that conclusion depends upon what the prior art discloses with respect to those parameters. Where, as here, the prior art disclosure suggests the outer limits of the range of suitable values, and that the optimum resides within that range, and where there are indications elsewhere that in fact the optimum should be sought within that range, the determination of optimum values outside that range may not be obvious. We think it is not on the facts of this case (In re Sebek, 175 USPQ 93, 95 (CCPA 1972)).

The reference identifies the range of below 200°C as preferable for this process step and further identifies undesired results from **exceeding** the preferred range of 200°C. Contrary to the assertions in the official action, those of ordinary skill in the art would not be motivated to exceed a temperature of below 200°C, as the reference clearly identifies reasons not to exceed this temperature. Why would one be motivated to use a temperature which is suggested to increase the likelihood of dewetting? There simply is no motivation to increase the temperature in view of the express negative results from higher temperature. As a matter of law there is no motivation to exceed the identified range of below 200°C.

As to the second point, it was suggested by the examiner that the claimed temperature range of 250 to 300°C, would have been the obvious result of optimization. Applicants respectfully submit that there is no suggestion to optimize the temperature of the cold

deposition process step to be within the range of 250 to 300°C, as there is no teaching that a higher temperature is a result effective variable.

> A particular parameter must first be recognized as a result-effective variable, i.e., a variable which achieves a recognized result, before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation. *In re Antonie* 195 USPQ 6, (CCPA 1977) (MPEP 2144.05)

In the present case there is no identification of a recognized desired result from adjustment of the temperature and therefore there can be no motivation to optimize the deposition temperature to within the range of 250 to 300°C. Where is the motivation to adjust the temperature range beyond the identified range of below 200°C? What desired result would be achieved by adjustment of the cold deposition temperature to be optimum? Since there is no identified desired result from the cold deposition temperature, as a matter of patent law there is no suggestion to optimize the cold deposition temperature and therefore the claimed temperature range of 250 to 300 °C is not obvious.

In contrast, the present invention is directed to a process in which a seed layer of metal, which may be Al, is formed on a first substrate surface which is Ti, at a substrate temperature of from 250-300°C. The claims recite deposition onto a surface which is Ti, **at a substrate temperature of from 250-300°C** .

As the cited reference provides no disclosure or suggestion of the claimed substrate temperature range of 250 to 300 °C the claimed invention is neither anticipated nor obvious over the cited reference.

Xu fails to disclose or suggest a method in which the first amount of metal is deposited at a substrate temperature and power sufficient to inhibit formation of a filamentous metal phases having a resistivity greater than that of the metal and inhibit void formation in an opening having an aspect ratio of at least 2.0

Xu fails to disclose or suggest depositing the second amount of metal at a substrate temperature and power sufficient to inhibit formation of a filamentous metal phases having a resistivity greater than the metal and to inhibit void formation.

Quite simply Xu does not describe substrate power conditions for the deposition of the metal layer in any great detail and is completely silent as to using conditions which can inhibit the formation of filamentous phases having a resistivity greater than that of the metal. The deposition conditions for depositing the metal onto the seed layer are not described in any detail. Neither of process examples 1 or 2 describe the deposition of the Al metal layer. At column 8, lines 25-28 is a simple description of a two-step process, first a cold deposition and then a hot deposition. At column 24, lines 44-61 is a further description of forming a seed layer at low-temperature, followed by a hot deposition. There is a further description of adjusting the DC target power to deposit the 800 nm of hot aluminum in the given time. There is no description of adjusting the substrate power sufficient to inhibit the formation of filamentous metal phases having a resistivity greater than that of the metal. There is no description of the deposition conditions whatsoever in terms of the formation of filamentous metal phases having a greater resistivity than the metal being deposited. Therefore, in the absence of any specific deposition condition and the absence of any recognition of the

prevention of the formation of filamentous metal phases having a greater resistivity than the metal being deposited the cited reference can not render obvious the claimed process. The claim limitation of "a substrate temperature and power that are sufficient to (i) inhibit formation of filamentous metal phases having a resistivity greater than that of said metal, and (ii) provide a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0" is a claim limitation which is simply not found in the cite reference and accordingly, the claimed invention can not be found to be rendered obvious thereby.

Xu Fails to Disclose or Suggest a Method in Which the Metal Is Deposited on a Seed Layer in at Least Two Steps.

The examiner commits reversible error in concluding the claimed invention to be obvious in view of the reference of Xu which fails to disclose a process in which metal is deposited onto a seed layer in at least two steps.

As previously described Xu describes a cold-hot sputtering process in which a seed layer is formed by a cold sputtering process followed by **a single** hot sputtering process. Only a single deposition step is described after formation of the seed layer by cold sputtering.

In contrast, the claimed invention is practiced by depositing an amount of metal onto a seed layer of metal, **followed by deposition of a further amount of metal** (e.g. step iii of claim 1). The claim limitation of depositing a further amount of metal onto the surface of the metal deposited onto the seed layer of metal, is a claim limitation which is not found in the cited reference. The examiner commits reversible error by concluding the claimed invention to be obvious, when the reference clearly fails to disclose or suggest Applicants' claim

limitation of depositing a further amount of metal onto the surface of the metal deposited onto the seed layer of metal.

In his rejections, the examiner points to figures 16 and 17 as teaching the claim limitation of depositing a further amount of metal onto the surface of the metal deposited onto the seed layer of metal. No such teaching is found in these two illustrations which simply illustrate a via hole (fig 16) and a via hole after its metallization (fig 17). There is no suggestion from these figures or in the specification of depositing the metal in at least two portions onto the seed layer of metal.

Claims 1-21 and 24 have been rejected under the judicially created doctrine of obviousness-type double patenting over Claims 1-24 of U.S. 6,140,228.

U.S. '228 does not claim deposition onto a liner layer which is Ti nor does it claim deposition of a seed layer at a temperature of from 250-300°C. As such, the claimed invention is clearly not obvious under the judicially created doctrine of obviousness-type double patenting as the claim limitations of a Ti liner layer and a seed layer deposition temperature of from 250-300°C are not disclosed or suggested in the reference. In order to support a rejection for obviousness-type double patenting, there must still be a disclosure or suggestion of each and every claim limitation.

> We decline to extract from Merck the rule that the Solicitor appears to suggest -- that regardless of how broad, a disclosure of a chemical genus renders obvious any species that happens to fall within it. In re Jones 21 USPQ2d 1941 (Fed.Cir. 1992)

The absence of the disclosure or suggestion of the Ti liner layer or the deposition temperature of 250 to 300°C precludes a conclusion of obviousness-type double patenting.

Accordingly, the rejection under the judicially created doctrine of obviousness-type double patenting is in improper and must be withdrawn..

Claims 22-23 have been rejected under the judicially created doctrine of obviousness-type double patenting over claims 1-24 of U.S. 6,140,228 in view of Xu.

These claims are directed to a method of forming a layer of Al on substrate surface comprising titanium, in which the seed layer is formed at a substrate temperature of 250 to 300°C.

U.S. '228 in combination with Xu does not disclose a seed layer formed at a temperature of from 250-300°C. As such, the claimed invention is clearly not obvious under the judicially created doctrine of obviousness-type double patenting as the claim limitation of a seed layer deposition temperature of from 250-300°C is not disclosed or suggested in the reference. In order to support a rejection for obviousness-type double patenting, there must still be a disclosure or suggestion of each and every claim limitation.

> We decline to extract from Merck the rule that the Solicitor appears to suggest -- that regardless of how broad, a disclosure of a chemical genus renders obvious any species that happens to fall within it. In re Jones 21 USPQ2d 1941 (Fed. Cir. 1992)

The absence of the disclosure or suggestion of the deposition temperature of 250 to 300°C precludes a conclusion of obviousness-type double patenting. Accordingly, the 's rejection under the judicially created doctrine of obviousness-type double patenting is improper and must be withdrawn.

Applicants submit this application is now in condition for allowance and early notification of such action is earnestly solicited.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.

Richard L. Chinn

Richard L. Chinn, Ph.D
Attorney of Record
Registration No. 34,305

Customer Number
22850

Telephone: (703) 413-3000
Facsimile: (703) 413-2220
RLC:dbl